evolved improved methods of progression. The most of them have returned to the quadrupedal condition, if we may conceive the four-footed baboons to have arisen in this manner. As to whether any of them have gained the perfected bipedal condition, it is perhaps best to make no assertion. Those who hold that man had an ape-like progenitor, must accept this view.

There are other mammals with partially bipedal habits. These compromise the jumping animals, the kangaroos, jerboas, etc. But in these cases there has been no specialization of the fore-limbs. They have simply become partly aborted. The bear also, through its plantigrade feet, and perhaps its climbing habit, has gained imperfect bipedal powers, and a grasping habit with its fore limbs. But there has been no specialization of these limbs. They continue true walking organs.

In the reptilian world other instances of bipedal habits present themselves, developed in still another manner.

The animals thus organized are all creatures of a vanished age—the huge Deinosaurian reptiles presented to us in the geological record. These creatures may have gained their specialization of form through the same cause, though not in the same manner, as the giraffe gained its special formation. Many of them lived by browsing on the foliage of trees. And these, instead of developing an elongated neck, like the giraffe, probably obtained their food by a partially climbing process. Their fore limbs clasped the tree trunk, while their weight rested on the hind limbs and the tail. In this manner they were able to reach the desired food.

A long continuance of such habits would produce, through selection, a specialization of the fore limbs. To become efficient organs for grasping tree trunks, they must have become inefficient walking organs. Through this specialization the fore limbs seem to have become small and comparatively weak, the hind limbs large and powerful. To look at the remains of these creatures now, as preserved for us in the rock strata, it seems as if a quadrupedal motion must have been very awkward and inefficient; while their habit of erecting themselves on their hind legs, may have rendered a bipedal motion easy and natural. Professor E. D. Cope says of them: "some have chiefly squatted, some leaped on their hind legs like the kangaroo, some stalked on erect legs like the great birds, with their small arms hanging uselessly by their sides." Yet when we consider the great size of these reptiles, which comprise the huge Iguanodon and Megalosaurus, the Hadrosaurus of our New Jersey marl, and other such gigantic creatures, we may well imagine that they presented an appearance widely different from that of any existing creatures. To see animals thirty feet in height and huge in proportion, to whom our elephant would be a mere pigmy, stalking about erect on their hind legs, would certainly be an astonishing spectacle. Yet such a view was very probably presented by that bizarre world of the past which time has swept away.

These Deinosaurian reptiles, with their peculiarities of structure, their hollow bones, and their three-toed feet, presented certain strong affinities to the great land birds of modern times. So close, indeed, that some have conjectured that these large wingless birds, such as the Ostrich, are direct descendants of the Deinosaurs. In this claim there are no powers of flight to be explained, yet the possession of feathers by the ostrich seems a fatal obstacle to the hypothesis. Feathers are a highly specialized form of dermal covering. They are specially adapted to purposes of flight, and we can imagine for them no other use which the less specialized hairs or scales would not have subserved. We are therefore disposed to conclude that any animals possessed of feathers must have gained them through powers of flight in themselves or their ancestors; and that the resemblances in organization above mentioned arose from similarity in modes of progression, and not from hereditary connection.

How, then, was the further step in the process taken? The primitive hairy covering being gained, how did hairs develop into feathers, how were the imperfect bipeds among land animals succeeded by the perfect bipeds among flying animals, and how did motion upon the earth develop into motion through the air? It certainly did not arise as a result of leaping habits. We cannot imagine the spring of a kangaroo as so advantageously aided by an accidental conformation of the fore limbs, as to produce a natural selection of this conformation. If these leaping animals habitually sought to assist their flight by a motion of the fore limbs, then any membraneous expansion or special thickness of hairy covering would be advantageous. But none of those now existing have such a habit, and without it their leap could never become a flight.

(*To be continued.*)

THE NEW COMPRESSED AIR LOCOMOTIVE.

On the 13th ultimo a trial of a new engine built by the Baldwin Works, Philadelphia, took place on the Second Avenue Railroad, the result of the trial being on the whole satisfactory. Compressed air as a motive power for railway engines has been repeatedly tried already in this country and in Europe. At Paris and Nantes the Mekarski Air Engine has at different times been used with more or less success, at Glasgow. Mr. Scott Moncrieff has labored perseveringly to demonstrate the superiority of compressed air over steam for locomotive purposes, while in June last year Col. Beaumont produced (in London) an engine which was thought at the time to have eclipsed its predecessors in point of efficiency and small working cost. The "success," however, of these engines has been so very undecided, and the advantages they presented in point of cleanliness, and absence of smoke and noise, have been so counterbalanced by the cost of compressing and storing the air, that as yet we have heard of no line of railroad or tramway being *successfully* worked by compressed air.

Comparing the data obtainable from these engines with the result of the late trial, we find a decided superiority in the efficiency of the American engine which possesses several new and important features, and is the result of long experience and study of the subject by the inventor and patentee, Mr. Thos. Hardie, the Pneumatic Company's Chief Engineer.

A short description of the engine and its trial may not be uninteresting to our readers. In length and weight it is as nearly as possible the same as an average Elevated Railroad engine, the part usually reserved for the boiler being in this case occupied by the receivers for containing the air, four in number and of unequal lengths, having an aggregate capacity of 460 cubic feet, in which air is stored at a pressure of 600 lbs. per square inch. Inside the cab is a small boiler (the consumption of coal in which is nominal) through which air from the receivers is passed before being allowed to enter the cylinders. An automatic throttle valve on the supply pipe of this boiler regulates the pressure at which the cold air enters the boiling water. The air being thus heated expands and the pressure is of course considerably augmented, and in this hot, moist condition it passes into the cylinders, having a far larger percentage of efficiency than if it were allowed to do so in a cold, dry condition. There is thus by this means a great saving in the quantity of air consumed. The system of drawing air from the reservoir at a low pressure and expanding it by heat until it attains a working pressure of from 100 to 130 lbs. per square inch is, we believe, entirely novel, and in this respect the engine differs altogether from Col. Beaumont's machine, in which air was admitted to the cylinders at its initial reservoir pressure—1000 lbs., and then quickly cut off.

In a former engine built by the Pneumatic Company

the air, instead of being heated by a small boiler, was made to pass through a tank which was supplied at intervals with boiling water and recharged as soon as the water cooled. The present arrangement is the result of experience derived from its predecessor.

The valve gear is simple and is fitted with a variable expansion valve under the control of the engineer, by which the cut-off can be varied from 1-10th to 5-8ths of the stroke. The link is worked by "crossed" eccentric rods, the effect of this being to prevent *any* opening of the parts when the reversing lever stands in the middle notch. By this arrangement the cylinders are, when necessary, converted into vacuum pumps and are utilized to operate the vacuum brakes attached to the cars. It has been found that when using the air expansively while running, *i. e.*, with a quick "cut-off," the expansion is sometimes so rapid that towards the end of the stroke the pressure in the cylinders is less than the external atmosphere; to obviate the loss of power which would be caused by the vacuum thus created, valves are placed in the exhaust passages, which prevent any vacuum being formed. Another feature in the engine is the existence of a suction and delivery valve at each end of both cylinders, which render it possible when going down hill, or approaching a station, to convert the cylinders themselves into "compressors," by which the pressure in the reservoirs can be increased, thus utilizing the waste energy which is usually given off in friction against the brakes. This arrangement is so successful that no other brakes are required on the engine. There are several minor points in the construction of the machine which it is not necessary to mention here; we may, however, say in conclusion that the engine has been carefully studied in every detail.

At the trial, the engine started from 128th street with a pressure in the reservoirs of 580 lbs. per inch, and travelled as far as 42nd street, a distance of 4½ miles or thereabouts, stopping at every station, and loaded with three cars containing about 50 people. At 42nd street some switching was done, and the engine then returned to the starting place, reaching 128th street with a remaining pressure of 115 lbs.

These figures show that the train would have run from Harlem to South Ferry, the entire route of the Elevated Road. But in making any practical calculation, it must be remembered that four cars are often used instead of three, and that these four cars would often be loaded with 600 persons. This probably implies an additional weight of about thirty tons to that placed behind the Pneumatic Engine during the recent experiment.

The company must be congratulated on building a most successful engine.

UNIVERSAL ENERGY OF LIGHT.*

By Pliny Earle Chase, LL. D.,

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Force is generally regarded as a function of mass and velocity. The greatest known velocities which can be produced by central forces are wave velocities. The greatest known wave-velocity which appears to be universally diffused is the velocity of light.

Let $v\lambda$ = velocity of light; v_0=circular-orbital velocity at sun's surface $=\sqrt{g_0 r_0}$; v_3=Earth's mean orbital velocity; v_r = velocity of Sun's equatorial rotation; u_3= potential velocity of water at 0°C. $=\sqrt{2g \times 100 \times 1389.6}$ ft.; u_4 = potential velocity of water at its maximum density; u_5=potential velocity of water-evaporation= $\sqrt{2g \times 536.37 \times 1389.6}$ ft.; m_0, m_3, m_5, m_6=masses of Sun, Earth, Jupiter, Saturn; h_0=Earth's semi-axis major; h_2=height of mean oscillatory projection due to the combining energy of H_2O; t_a=time of acquiring circular-orbital velocity at Laplace's limit of synchronous rotation and revolution = time of rotation $\div 2\pi$; t_n = time of acquiring "nascent" or dissociative velocity at nucleal surface = ½ time of rotation $= \pi t_a$; χ =Weber's electrochemical unit; μ=electromagnetic unit; ρ_0=total magnetic force; ρ_3=terrestrial magnetic force; t_0=present value of t_n at Sun's surface; g_0=gravitating acceleration at sun's surface.

The simplicity of the relations of the universal velocity $v\lambda$ to other physical velocities, is shown in the following equations:

$$1.\quad \frac{v\lambda}{u_3} = \frac{h_0}{h_2} = \frac{m_0}{m_3} = \frac{t_n^2}{t_a} \cdot \sqrt{\frac{\rho_0}{\rho_3}}$$

$$2.\quad \frac{v\lambda}{v_0} = \frac{v^0}{u_4} \cdot \sqrt{2} = \frac{t_n}{t_a} \cdot \frac{v_0}{v_r}$$

$$3.\quad \frac{v\lambda}{g_0} = t_0$$

$$4.\quad \frac{v\lambda}{v_3} = \sqrt{\frac{m_0 m_5}{m_3}} = \frac{m_0 t_a}{m_3 t_n} \cdot \sqrt{\frac{\mu}{\chi}}$$

$$5.\quad \frac{v_5}{u_5} = \frac{3^4 m_0}{2 m_6} = \frac{5 \times 3^3 m_0}{m_5}$$

The velocity of solar atmospheric rotation, at the secular mean centre of gravity of the solar system, is also equivalent to u_5.

The law of conservation of areas, in an expanding or contracting nucleus, requires that g_0 should vary inversely as t_0. Equation 3 should, therefore, hold good for all stages of solar existence, past, present and future.

The values which satisfy the above equations are: m_0=328470 m_3; h_0=92476500 miles; $v\lambda$ = 185760 miles; v_3=18.412 miles; u_3=2986 ft.; u_5=6916.2 ft.

The following table shows the accordance between theoretical and observed values:

	Theoretical.	Observed.
Boiling point of water........	99°.18	100°
Combining heat of H_2O......	69319	67616 to 69584*
ρ_6........................	140.65	140 lb. pr. sq. in.
Maximum density of water....	4°.19	3°.33 to 4°.85
v_3........................	18.31	18.41
Latent heat of steam.........	536°.374	536°.385 †
$\chi \div \mu$........................	107.38	106.67

The velocity of light is also a factor of electromotive energy. Weber and Kohlrausch demonstrated this fact by measuring quantity of electricity; Thomson and Maxwell, by measuring electromotive force; Ayrton and Perry, by measuring electrostatic capacity.

Perhaps the most interesting of the above indications is the past, present and future equivalence of Sun's "nascent" velocity to the velocity of light; the sum of the cyclical reactions of solar superficial gravitation against the actions of external gravitation, during each half-rotation, being *equivalent to the velocity of light.*

The Metal Actinium, by J. L. Phipson. — The author stated that he had been able to separate a new element from the pigment zinc-white. The oxide of the new element is said to be slightly soluble in caustic soda, and is soluble in ammonia and ammoniacal salts. Its color is uninfluenced by exposure to light. The sulphide of actinium is described as a pale yellow canary-colored substance; it is insoluble in ammonium sulphide, is soluble in acetic acid, and becomes darker on exposure to the air.—*British Association*, 1881.

* Read before the American Association for the Advancement of Science, August, 1881.

* The mean of six estimates, cited by Naumann, is 68886.

† This is the mean of four estimates, viz.: Favre and Silbermann, 535°.77; Andrews, 535°.90; Regnault, 536°.67; Tyndall, 537°.20.